QUALITY OF WATER IN ILLINOIS STREAMS[1]

By Minna E. Jewell

Heretofore the method of judging the sanitary quality of water of a stream has been to approximate the stream flow and the volume of sewage discharged into it. The errors of this method are obvious. In the first place, engineers do not claim any great degree of accuracy in such estimates as are ordinarily carried out. Second, sewages differ greatly in concentration. Third, granted the same concentration of sewage and the same degree of dilution, a small river purifies itself much more readily than a large one because of the relatively greater surface exposed to the air.

The United States Geological Survey published in 1910 mineral analyses of water from the principal Illinois rivers. The mineral analysis alone might tell us much concerning the quality of water in a natural unpolluted stream, but unfortunately there are few if any such streams in the state today, and the mineral analysis is no criterion to the quality of a polluted water.

Polluting materials may be roughly divided into two classes: (1) substances which harm the water by absorbing oxygen and producing toxic substances during their decomposition, such as domestic sewage and waste from starch plants, slaughter houses, and canneries, and (2) substances which are in themselves toxic, such as waste from gas works, mines and acid factories. Thus far the investigation of Illinois waters receiving waste of the second class (industrial waste) has been confined to studies of acid wastes from acid and munition plants, of which there are several in the state, and a few observations on mine waters. Due to the high alkalinity or hardness of most of the waters of the state the effects of acid wastes are purely local. The acid entering a stream is usually neutralized within a short distance of its point of entrance. It is pollution of the first of these two classes (domestic sewage and wastes which have a similar action) which is the problem of Illinois today.

[1]Read before the Illinois Section on March 26, 1919.

It is well known that as a stream becomes polluted the fish first to disappear are the more sensitive ones like trout, blue cat, eel and wall-eyed pike. As conditions grow worse these are soon followed by channel cat, mud cat, sucker, buffalo and native carp, and finally by such resistant forms as the dog fish, bull head, gizzard shad, and black bass, and last of all the German carp. But the presence of fish can not be used as a criterion of the damage done a river. At times of heavy rains fish may swim upstream or come in from tributaries, so that cat or buffalo may be found in a location where at low water even a German carp could not survive. It is known, however, that any water which will support cat or buffalo will also support the heavy shelled gill-breathing snail; bryzoa or moss animals, the same forms which sometimes cause so much trouble in water mains, should be abundant on stones, shells and submerged vegetation; fresh water sponges should be found on the underside of logs; while the delicate nymphs of the May fly, caddice fly and other insects should be abundant on stones in the riffles. These organisms can not migrate in or out of the locality, hence they tell the best story of conditions in the river. Whatever the quality of water at the time of the examination, unless an abundance of these organisms is found, we know that at some season the quality of the water is very poor, too poor for fish life.

The Sangamon River, upon which much of the author's work has been done, furnishes a typical example of a seriously polluted stream. It reaches Decatur as a small, relatively normal stream. Decatur derives its water supply from the river and as the demands of the town are greater than the flow of the stream at low water, there are several weeks each summer, and in case of a dry winter, a few weeks in the winter, when no water whatever passes the Decatur dam. This means that at such times the entire flow in the river below Decatur is crude undiluted sewage. As the Sangamon receives no important tributaries for at least 100 miles of its course, the changes which take place progressively are primarily due to the decomposition of the sewage.

Now what are the conditions in the Sangamon River shown by the biological survey? Not one of the organisms above mentioned is found between Decatur and Roby, fully 75 miles below. From Decatur to Harristown, a distance of about 20 miles, the only organisms found are moulds and bacteria; masses of slimy whitish-grey mould coat the stream bed and hang in heavy festoons from

every rock and twig, but not even sludge worms can tolerate the conditions which develop in this part during the late summer. Samples taken in only 3 feet of water last October showed no dissolved oxygen whatever.

At Niantic, some 15 miles farther down, the moulds are decreasing noticeably and the first sludge worms (tubificids) occur in the bottom. These worms are remarkable for their ability to live in the complete absence of free oxygen, just as some bacteria do. In late summer the only animals found free in the water are infusoria and foul-water rotifers, microscopic animals capable of living without ogygen and under conditions of rapid putrefaction, and minute round worms which are found in the floating tufts of mould. At the time of the spring rains, however, fish may be found at Niantic but these fish go down with the floods. Those which do not are soon gulping at the surface and dead along the shore. The odor of the Sangamon River between Harristown and Niantic can sometimes be detected at the distance of a mile.

From Niantic the number of tubificid worms in the bottom increases rapidly, so that in 10 or 15 miles the mud of the bottom seems alive with them.

South of Illiopolis, or about 50 miles by river below Decatur, the first trace of oxygen is found in the water of the bottom and with this one of the hardiest of insect larvae appears, the so-called blood worm or chironomid larva, frequently the cause of annoyance in city reservoirs. In a few more miles cray-fish may be found.

At Roby, about 75 miles below Decatur, there is a mill with a rather high dam across the river. This retards the movement of the water and allows the settling-out of organic matter to form a thick sludge on the bottom. Oxygen completely disappears from the deep pool above the dam, but as the water pours over the dam and rises in spray below, it becomes mechanically aerated so that shortly below the dam are found mussels or river clams, gill-breathing snails, fingernail shells and many kinds of insect larvae. In other words, the water below the dam is suitable for resistant fish such as German carp and bullhead. From this point, improvement is rapid. A short distance above Springfield, the relatively unpolluted South Fork enters, almost doubling the volume of water in the river. However, recovery is not complete even at Springfield. The more delicate organisms are still lacking. Below Springfield the river is again polluted by sewage, so it is not until Petersburg

is reached some 50 miles below Springfield that we again find normal conditions.

So much for the biological survey. The river is polluted, rankly polluted, the biological examination shows it, our eyes see it and our nose smells it, it is said, at a distance of two or three miles, but how can we measure quantitatively the amount of pollution at different points? At first, we might think dissolved oxygen would be a good criterion. Where there is no oxygen there are only sewage animals, and where oxygen increases the number of normal river animals increases, but that applies only to the later summer condition. Because of the higher solubility of gases in cold water and the slower decomposition of sewage, there is always an abundance of oxygen in the water during the winter except when the river is frozen over so as to exclude the air. Oxygen determinations made in February at Niantic, where the water was full of floating masses of bacterial slime and mould, showed 63 per cent of saturation, whereas only 54 per cent was found at Springfield in August.

Dissolved oxygen appears to be a fairly good index to pollution during the summer, and has the advantage of being readily determined in the field and requiring but little apparatus. The complete sanitary analysis, on the other hand, requires an equipped laboratory, but by the time a sample is collected and sent into the laboratory, say it requires a day or two in transit, it has undergone changes so extensive as to render it utterly worthless for this type of work. A sample of water allowed to stand in the laboratory six days showed over twice as much free ammonia as a similar sample analyzed immediately after collection.

Through the kindness of Mr. Spaulding, Commissioner of Public Works at Springfield, the author was able to set up apparatus in the meter-testing laboratory at Springfield, and could thus bring samples into the laboratory and begin the analysis before they had even changed appreciably in temperature. Of the various determinations of the sanitary analysis, oxygen consumed, nitrates, nitrites, etc., one in particular, the organic nitrogen, appears to vary according to the pollution. Starting with 0.7 p.p.m. at Decatur, we find a sudden rise to 2.2 p.p.m. at Niantic some 35 miles below Decatur, and then a gradual decrease to normal, 1.72 at Illiopolis, 1.2 at Roby, 0.8 at Springfield.

Samples of mud from the bottom of the river were also analyzed. It has already been remarked that the animals from the bottom are

a better index to the condition of the stream than the animals free swimming in the water because they are less influenced by temporary conditions, such as those caused by rain. The same thing is true of samples for chemical analysis. Mud samples taken after rains showed practically the same composition as those taken under normal conditions although the water samples were absolutely different. The ammonia and organic nitrogen of these samples were determined and (expressed as percentages of solid matter because there is always more water in some samples than in others) they show an abrupt rise below Decatur, followed by a gradual decrease to Petersburg, at which point the last sample was taken. Thus for ammonia we have Decatur, 0.0062; Niantic, 0.054; Illiopolis, 0.053; Roby, 0.021; Springfield, 0.0112; and Petersburg, 0.004; and for organic nitrogen, Decatur, 0.22; Niantic, 0.42; Roby, 0.27; Springfield, 0.224, and Petersburg, 0.11; so that if we plot concentration as ordinates with distance as abscissas we get a characteristic curve falling gradually at first, then very rapidly and then more gradually again to the normal.

The author is not prepared to say that any stream whose bottom mud shows over 0.01 per cent ammonia and 0.25 per cent organic nitrogen is seriously polluted nor that any stream whose mud shows over 0.02 per cent ammonia and 0.3 per cent organic nitrogen will kill off all but the hardiest fish and smell badly in summer. Work on a single river through a part of a year warrants no generalizations. Yet from the similarity of results already obtained in work on other rivers (the Embarrass, Muddy and Okaw are also under investigation), the author feels justified in the belief that by the time a number of rivers have been carefully studied for a period extending over a year some criterion will be found (perhaps not so simple as the example just given but still simple enough to be practical) for expressing quantitatively the pollution of a stream.

DISCUSSION

H. E. Babbitt: The author mentioned oxygen as purifying the water. May it not be possible that sedimentation is an important factor? Thus, the formation of the lakes on the Illinois River above Peoria gives a possibility for sedimentation and purifies the water.

M. E. JEWELL: The idea that running water purifies itself has a pretty firm hold on the popular mind. However, we find that the regions of a stream in which purification progresses most rapidly are where we have lakes alternating with riffles.

The statement that larger streams do not purify themselves as rapidly as smaller streams was based upon observations made upon the Illinois River last summer in the company of Mr. Richardson of the State Natural History Survey. The dilution of the Sangamon River is sometimes 0, sometimes 1 to 1 and sometimes 1 to 2. The dilution of the Illinois River is much greater, yet the Illinois River requires as long a distance to purify itself as the Sangamon does. If the Illinois River began as all crude sewage, as does the Sangamon below Decatur, the distance before purification would be accomplished would be much greater, probably not above Grafton. The reason the smaller river can purify itself more rapidly is because it allows more ready penetration of oxygen.

H. E. BABBITT: If the Sangamon River is worse than the Illinois, it must be terrible. The Illinois is as bad as possible below Joliet. The Illinois is a wonderful example of rapids and large lakes. The purification of the river is mainly due to oxidation until it reaches Peoria Lake, immediately above Peoria. This allows settling out and the water is in excellent condition when it reaches Peoria.

M. E. JEWELL: Coming down the Illinois there are no animals whatever in the bottom of the river, except sludge worms, until past Henry. From Henry to Lacon we begin to get a few so-called finger-nail shells. These animals are very resistant and can grow in the small amount of oxygen present. At Chillicothe we get our first appearance of gill-breathing snails. At Peoria narrows, we get the first appearance of the complete normal river bottom fauna. Sedimentation in the lakes is a most important factor, but an increase of oxygen also occurs there. Sedimentation is going on all up and down the river. The sewage settles on the bottom forming sludge, the decomposition of which is responsible for the depletion of oxygen at the bottom. The occurrence of oxygen at the bottom, then, means that the decomposition of this sediment is completed, at least to a certain stage.

At Hennepin last August, where there was no oxygen at the bottom, there was only a trace of oxygen at a depth of 6 feet,

although oxygen sufficient to support fish life was found at a depth of 1 foot. If water is 30 feet deep, the 1 foot of water at the surface which is supplied with oxygen will make no appreciable difference in the animal life. Bottom animals, as clams and snails, require less oxygen than the fish which swim in the water above, so allowance has already been made for the difference between the bottom and the water above. Where the bottom will not support these bottom forms, it has been found that the water will not support fish.